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Abstract

With climate change, coastal areas are faced with unprecedented sea level rise and flooding, raising questions as to how societies will choose to adapt. One option is to strengthen existing sea walls to maintain current land uses; however, scientists, policy-makers and conservationists increasingly see the benefits of managed realignment, which is a nature-based coastal adaptation that involves the conversion of reclaimed farmland back to wetlands, allowing periodic local flooding in designated areas to reduce the risk of flooding downstream. We interviewed sixteen local organisations, landowners and farmers, and held workshops with 109 citizens living the Inner Forth estuary in eastern Scotland, to examine how managed realignment is supported by stakeholder attitudes and their engagement.

Most of the farmers we interviewed prefer strengthened sea walls, to maintain their livelihoods and agricultural heritage. Citizens and local organisations were mainly supportive of managed realignment, because it provided wildlife and flood regulation benefits. However, we identified several barriers that could present obstacles to implementing managed realignment, for example, uncertainty whether it would support their principles of economic and rational decision-making. Our findings suggest that the local capacity to cope with rising sea levels is limited by lack of engagement with all relevant stakeholder groups, the limited scope of existing stakeholder partnerships, and poor short-term funding prospects of landscape partnerships that would facilitate collaboration and discussion. We suggest that including citizens, landowners, farmers and industries would strengthen existing stakeholder deliberation and collaboration, and support the Inner Forth's transition towards a more sustainable future shoreline.

1. Introduction

People have an innate preference to live close to the sea, and the majority of the world's population lives in low-lying areas in coastal settlements that depend on the sea for trade and livelihoods (Small and Nicholls 2003). For centuries, humans have actively transformed coastlines and estuaries by enclosing tidal land for settlements and agricultural purposes (Doody 2004, Agardy and Alder 2005). In modern times, construction of industrial ports and the extension of urban areas into the sea have continued this process (Rogers et al. 1998, McGranahan et al. 2007). These land claims have led to a significant loss of wetlands, such as salt marshes and mudflats (Mitsch and Gosselin 2007), affecting marine biodiversity and important ecosystem functions that characterize these intertidal habitats, such as carbon sequestration (Chmura et al. 2003), sediment trapping and retention (Adam 2002), and protection from waves during storms (Möller et al. 2014).

In addition to these longstanding land use changes, anthropogenic climate change is an emerging threat to estuarine ecosystems, most notably due to coastal squeeze (Scavia et al. 2002, Roebeling et al. 2013). Coastal squeeze is a common phenomena due to sea level rise in areas with developed shorelines, where infrastructure, such as sea walls, stop the intertidal zone from its natural process of moving landwards (Doody, 2004). Combined with population growth and urban expansion in coastal cities, pressures exerted on estuarine ecosystems are increasing (McGranahan et al. 2007). As a result, people are increasingly exposed to coastal flooding (Small and Nicholls 2003). This is a global trend, and is particularly pressing in Scotland, where more than 95% of the population live within 50 km of the coast (European Commission 2013) and where coastal flooding and erosion are concerns that require immediate action (UK Committee on Climate Change 2016). Flood damages are expected to cost £200-250 million in Scotland annually in 2016-2021 (ClimateXChange 2016; Pirie 2017), which is 7-8 % of Scotland's education budget in 2016 (Scottish Government 2016a). Coastal flooding is estimated to contribute 21% of the monetary cost of flood damages.

There are two main climate change adaptation options for coastal flooding: static and nature-based. The first, more traditional engineering option is the static approach to shoreline defences, where constructed barriers, such as sea walls and piers, protect urban, industrial or otherwise human-used areas from flooding (Zhu et al. 2010). The second option is to restore the wetlands that characterize many estuarine areas for nature-based coastal adaptation (King and Lester 1995). Wetland protection and restoration can play an essential role in decreasing the risk for coastal flooding in those areas that are most vulnerable to sea level rise (Spalding et al. 2014). The deliberate moving inland of coastal defences such as levees to give more space to the sea, an approach known as managed realignment, has been suggested to be the only viable option in the long term for some coastal areas (Morris 2013). Moving vulnerable settlements and infrastructure from harm's way would improve coastal adaptation in the long-term (Esteves 2014) and create habitat benefiting a variety of species (Colclough et al. 2005).

The planning and implementation of coastal adaptation can be hindered by a multitude of factors related to governance, policy goals, and people's perceptions (Ledoux et al. 2005, Morris 2013), as well as economics (Turner et al. 2007), hydrology, and ecology (Spencer and Harvey 2012, Doody 2013). Many of these factors can

prevent the implementation of managed realignment schemes, although examples of successful managed realignment pilot projects exist in the UK (Midgley and McGlashan 2004). Moreover, managed realignment is increasingly used for coastal habitat compensation in the UK, although it is unclear whether this actually leads to net benefits for biodiversity (Brady and Boda 2017).

Studies by Ledoux et al. (2005), and Wiering and Arts (2006) reveal that the public perceives managed realignment as admitting defeat against the sea and a threat for productive land, particularly in times of climate change and sea level rise when agricultural land is already becoming increasingly scarce. If avoiding admitting defeat against the sea is a strong cultural norm, defined as "typical or expected standard or behaviour" (Oxford Dictionary 2017a), we argue that it represents a powerful informal institution (Hansen et al. 2014) that influences coastal adaptation efforts and the discussion with various stakeholder groups. This requires an understanding of formal and informal institutions, understood as the structures or mechanisms that influence our behavior in society, or in other words "the rules of the game" (North 1990). According to Williamson (2000), formal institutions are for instance governance structures, policies and laws set by authorities at the national or regional level. By contrast, informal institutions are for example traditions, values, customs or practice "in the political or social life of a people" (Oxford Dictionary 2017b). Recognising these informal elements of governance, including norms, can shed light on why there is reluctance amongst local communities to retreat sea defenses landward, which may in turn impede the implementation of managed realignment (Ambros 2016; Foster et al. 2013; Luisetti et al. 2011).

Managed realignment is currently under increasing local interest and debate in the case of the estuarine area in the Inner Firth of Forth (hereafter referred to as the Inner Forth), Scotland (Fig. 1 in Liski et al. 2019, this issue). Over 50 percent of the former wetlands in the intertidal area in the Inner Forth has been reclaimed (via land draining and building sea walls) in the last 400 years for farming and industrial uses (SNH 2011). Most of the areas that were claimed from the sea were wetlands that are now owned and used by individual farmers and the local authorities. Due to its low elevation, closeness to the sea, climate change and sea level rise, these lands are increasingly vulnerable to coastal flooding. Yet, given coastal development, there is less space to absorb excess water and the damage to property and built infrastructure elsewhere is higher. Locally observed trends in sea level rise in recent decades are already in line with the high emissions scenario (Rennie and Hansom 2011) that projects sea level rise for the Inner Forth region of about 30 to 54 cm by 2080 (central to high-end estimates, Lowe et al. 2009), requiring the Inner Forth, like many other coastal communities, to choose its adaptation pathway: will they continue to rely on the current sea walls or give space back to the sea?

1.1. The governance context

A variety of different actors, representing civil society, the government and industry interest groups, are key in the governance in the Inner Forth area and coastal management. At the local level, a prominent example is the Inner Forth Landscape Initiative, a partnership that brings together many organisations to encourage both ecological and economic regeneration of the area (Inner Forth Landscape Initiative 2017). It involves four local authorities (Falkirk, Stirling, Clackmannanshire and Fife), the Central Scotland Green Network Trust, the Scottish

Environmental Protection Agency (SEPA), Scottish Natural Heritage (SNH), Historic Scotland and Sustrans, and strongly emphasizes the involvement of stakeholders and local people (Kenter 2014).

Nationally in Scotland, the two government agencies, SEPA and SNH, are responsible for flood protection and nature conservation respectively, and providing legal advice to existing or new legislation. In addition, both organizations also have an advisory role to other public stakeholders, such as local authorities. The local authorities are in turn obliged to comply with national legislation and European Union directives, for example the Flood Risk Management (Scotland) Act (2009), Climate Change (Scotland) Act (2009) and the EU Water Framework Directive (2000/60/EC). The implementation of these legislations should, in principle, be reflected in the local authorities' management plans. However, due to the differences in geography, development, interests and political leadership, the local authorities comply with legislation in separate ways.

The statutory process of coastal adaptation has been set by The Flood Risk Management (Scotland) Act 2009. The act includes several measures for flood risk management in Scotland, for instance, the preparation of local flood risk management plans to fulfil the requirements on a local level (Scottish Government 2016b). The plans for the Inner Forth were recently published as part of a plan for the entire Forth Estuary (City of Edinburgh Council 2016). The plan does not include managed realignment or other nature-based approaches to flood management in the Inner Forth, despite numerous sites being recognized as potentially vulnerable to coastal flooding, and the presence of several sites that would be suitable for managed realignment. However, the document does indicate plans to assess opportunities for natural flood management measures in the future.

Many other national policies also directly impact coastal management. In Scotland, landowners have the primary responsibility to protect their land and property, and there are no incentives for land use or management that would improve flood safety in vulnerable areas (Scottish Government 2014). The current coastal management strategy is almost solely based on static flood defences in the form of sea walls that were introduced between 400 - 40 years ago as wetlands were drained and converted for agricultural and industrial uses (Smout and Stewart 2012). For privately owned land, such as agricultural land adjacent to the sea, the responsibility for flood protection lies with the landowners, mainly via maintaining existing sea walls. Under the Coast Protection (UK) Act (1949), landowners have been given the right and duty to maintain these sea walls and keep a static defence towards the sea.

On the European level, the existing institutional arrangements, such as rights and responsibilities of different institutions involved in marine and coastal management are often complex and unclear (Boyes and Elliot 2014; 2015). How the UK's decision to leave the EU will affect policies that have been designed at the EU level is an important yet open question for coastal management. For example, it is not yet clear whether and how policies are transposed to a national level, and whether the downscaling of policies will convolute responsibilities in coastal planning and policy.

1.2. Aims and objectives

In this paper we investigate how current governance arrangements are aligned to support societal responses to the increased risk of coastal flooding in the Inner Forth. The following three research questions guide the research on how citizens' and other stakeholders' attitudes, and current stakeholder engagement, support coastal adaptation to climate change in the Inner Forth.

RQ1 How do local stakeholders perceive the two alternative coastal adaptation options (reliance on the existing sea walls and nature-based coastal adaptation)?

RQ2 Which institutions govern the Inner Forth shoreline from a citizen perspective?

RQ3 How does existing stakeholder engagement support climate change adaptation on the Inner Forth shoreline?

2. Methods

To collect data to address the above three research questions, we employed a suite of methods, presented as four steps in Table 1. Step 1 involved 'stakeholder mapping' through 16 semi-structured interviews with local landowners, farmers and locally active organisations (two conservation charities, a private agricultural estate and two government agencies) who are involved in coastal adaptation in the Inner Forth. Semi-structured interviews (Babbie 2013) of approximately 60 min were conducted with relevant stakeholders (Step 2, Table 1) in February-March 2016 and October 2016. Furthermore, we recruited and engaged with a total of 109 citizens living in the Inner Forth through five workshops (steps 3 and 4, see Table 1).

<< insert Table 1 >>

We interviewed sixteen stakeholders representing seven different organisational types and roles, including: i) seven farmers, owning land potentially subjected to managed realignment, ii) representatives from three (out of four) local authorities, iii) two government agencies (Scottish Environment Protection Agency and Scottish Natural Heritage), iv) an estuary partnership organisation (Forth Estuary Forum), v) the locally active conservation charity Royal Society for the Protection of Birds (RSPB), vi) the Scottish Wildlife Trust, and vii) one private agricultural estate. Although we identified sixteen farmers as potential stakeholders, nine farmers could not or did not want to be interviewed. The fourth local authority, Stirling, was not interviewed because they do not own or manage any coastal land holdings.

We organised five workshops with a total of 109 citizens in October 2015 - February 2016 in Alloa, a town on the shore of the Inner Forth. Participant recruitment and workshop programme are summarised in Steps 3 and 4

in Table 1. The full details of citizen engagement are described by a parallel paper Liski et al. (2019; this issue), which examines how deliberation shapes citizens' attitudes towards managed realignment. This paper compares and contrasts the attitudes of citizens with the perceptions of other stakeholders to achieve a more rounded view of local-scale adaptation dilemmas in the Inner Forth. In total, we have collected data from twenty break-out groups (four groups in each workshop) to analyse the main points that were raised during the discussions.

Both the stakeholder interviews and the citizen workshop discussions were recorded and transcribed. The process of content analysis differed for each research question, as described next.

2.1. How do stakeholders perceive the two alternative coastal adaptation options? (RQ1)

From the interview transcripts, comments relating to either static defences (seawall) or nature-based coastal adaptation were identified and assigned to one of the two coastal management approaches. We also identified all motivations for their positions on static and nature-based coastal adaptation, to identify common reasons or norms supporting or hindering coastal adaptation. Quotations are included to illustrate findings, but these are not attributed to stakeholders to avoid revealing their identities.

For the citizen workshops, content analysis of transcripts was carried out for the first part of the discussion (Step 3 in Table 1). We identified comments about either the potential sites for managed realignment, or participants' motivations for supporting or opposing wetland restoration. If appropriate, these were coded according to the extent of support for nature-based coastal adaptation.

2.2. Which institutions govern the Inner Forth shoreline from a citizen perspective? (RQ2)

To understand citizen's perceptions of shoreline governance, content analysis was carried out for transcripts from the second discussion-based exercise (Step 4, Table 1): we identified and coded institutions that participants perceived to govern the shoreline areas, and counted the frequency of mentions from the mindmaps. The discussion in most groups, however, broadened in scope to cover issues beyond immediate shoreline areas. To maintain focus on coastal adaptation, we excluded institutions that only relate to issues beyond the shoreline.

2.3. How does stakeholder engagement support shoreline adaptation in the Inner Forth? (RQ3)

For stakeholder interviews, mentions of collaborations and interactions with other stakeholders regarding coastal management were identified to understand how stakeholder engagement currently supports coastal adaptation. These were coded according to spatial scale of governance. We also identified and coded any mentions of factors that limit the extent to which these collaborations drive adaptation.

For citizen workshops, we identified examples of how citizens felt they were informed and included in local planning and policy. Here too, quotations are included to illustrate findings, but these are not attributed to individuals to avoid revealing their identities.

3. Results

3.1. How do stakeholders perceive static and nature-based coastal adaptation?

Based on their land owership and existing property rights and responsbilities, the private landowners, farmers and the private estate had the highest stake in decisions regarding shoreline management, whereas the RSPB and the estuary partnership had the lowest stake (Fig. 1). The RSPB and Clackmannanshire residents were the most supportive of nature-based coastal adaptation, whereas the private landowners, farmers and the private agricultural estate were the only stakeholder groups that did not support nature-based coastal adaptation (Fig. 1). The stakeholder motivations and stakes in shoreline management are described in more detail below.

<< Insert Fig. 1 here >>

3.1.1. Farmers and locally active organisations (RQI)

The seven farmers we interviewed (Fig. 2a), who manage most of the land suitable for creating nature-based coastal adaptation, prefer static defences, whereas the private estate (largest landowner in the area) is supportive of nature-based coastal adaptation. Farmers attributed their reluctance to managed realignment to three main reasons: the effects on their land and resulting economic losses, the desire to maintain their agricultural heritage, and their awareness of unsuccessful nature-based flood risk management schemes in the area.

<< Insert Figs. 2a-2b here >>

Sustaining livelihoods was the main reason why the farmers preferred static defences, as managed realignment would result in the loss of land area where they could grow crops, and consequently loss of crop yields. Agriculture generated 25-100% of the income (67% average) for the seven farmers we interviewed. For the private estate, the "main aim is trying to preserve income from the land: if it is under water, it would probably not be very much land". This motivation was also linked to family heritage, for example, one of the farmers mentioned how it was important to "make a living and leave something for the boys to carry on with, I have two sons". Another farmer we interviewed was motivated to farm "to progress so the next generation can carry on". Concerns over past experiences, for example in the Skinflats nature-based flood management scheme, where an engineering fault resulted in erosional impacts on adjacent farmland, were also reflected in their reactions to managed realignment: "No, don't think it would do any good for anybody, we have seen how bad it can get".

Representatives from the three local authorities (Clackmannanshire, Falkirk, and Fife), government agencies (SNH and SEPA) and the RSPB are mainly supportive of managed realignment (Fig. 1). Although none of the three local authorities we interviewed were opposed to managed realignment, they all prescribe a static shoreline defence approach in their coastal management plans. Furthermore, two local authority representatives noted concerns about the trade-offs arising from managed realignment as a nature-based coastal adaptation and had rejected proposals in the past, whereas the third local authority was not implementing any managed realignment schemes in the Inner Forth area. The government agencies were supportive of managed realignment: the first representative, however, noted that their support depended on careful planning, alignment with other coastal development goals and flood protection, whereas the second representative appreciated its potential for nature conservation.

The locally active organisations we interviewed describe three types of norms that contradict managed realignment in the Inner Forth. These norms relate to decision-making, their relationships with the private landowners, and preferences for land management approaches (Table 2). The first type of norm relates to their principles of evidence-based and economically rational decision-making, which are demanded by the broader economic and political systems in order to justify decisions. These norms were exemplified by concerns over the maintenance costs of nature-based coastal adaptation, and a notion that other social priorities (e.g. need for housing) are more important. The second type of norm, as described by one local authority representative, related to concerns that creating nature-based coastal adaptation would compromise their relations with the local farmers. The third type of norm was directly linked to attitudes towards nature-based land management, some of which were justified by the erosional issues in the Skinflats scheme mentioned earlier.

<< Insert Table 2 here >>

3.1.2. Deliberative citizen workshops (RQ1)

At the citizen workshops (Fig. 2b), we formed twenty groups of 3-7 people for discussion. The workshops revealed that their knowledge of the shoreline areas was limited, and most were unfamiliar with a majority of the sites where managed realignment is proposed. Only two out of the twenty groups explicitly mentioned the agricultural production currently occurring on potential sites for managed realignment. Some participants responded to the information provided in the workshops by noting that the Inner Forth might flood more frequently in the future, but only two out of 109 participants indicated that they had been aware of the flood risks before the workshops.

Despite the limited knowledge of the local shoreline, citizens in the workshops discussed several reasons why they support wetland restoration (Fig. 1). They noted how keeping "more nature in the area, [so] it would help with many of these other things. When it rains, there is somewhere for it [the water] to go". Many participants said that they "didn't know wetlands slow down flood water, or that it would remove pollutants, that is quite surprising to me, but blatantly obvious", and that their appreciation for wetlands had increased during the workshop as they gained more knowledge:

The wetlands, from what I have learned, are the most important feature on the banks of the river, and they should be increased, or at least, maintained, as well as possible. Just to broaden up the benefits of them, and the effects that not having them, or having less of them, could have on the community.

It was also recognised how nature brings emotional and physical wellbeing, such as the "sounds and the smells, [which] are all important, for providing the natural experience. When you are standing by the water, the smell of the flora, it is part of the experience of being part of these areas". One participant described the importance of spending time outdoors for her wellbeing:

I love walking by myself, you and your thoughts, it clears your mind. If I have got a lot on my mind, I'll just put my jacket on, and go for a long walk. Every time I come home, I'm so chilled, my mind is empty. It makes you feel good.

Managed realignment schemes were also perceived as intentional human interventions, which raised concerns, for example, one participant felt that it would be better to "… leave it alone, there is nothing wrong with [the potential sites for managed realignment]". One participant noted that the "instinct is to think that where it is good for nature and wildlife, it is basically stuff that has been left on its own for a while, and then [where there are] people, there is always going to be a conflict" and that it was "important to have places . . . where we can't actually go".

One of the groups that was aware of the farmland and flood risk also foresaw it to be difficult for the local landowners to accept managed realignment, saying: "I cannot see the farmers giving up their ground, to be quite truthful"; and noted the potential need for financial compensation: "I suppose there are ways of easing the pain for these things, like government subsidies". One of the groups who was concerned about coastal flooding discussed the responsibilities of the landowners to use their land with the effect on the broader community in mind, stating:

[The landowners] need to realise, although they own it, on a piece of paper that says it is theirs, if it is going to have an effect on everybody, the whole community, and potentially the wildlife, they need to kind of realise that their ownership is not there.

3.2. Which institutions govern the Inner Forth shoreline from a citizen perspective? (RQ2)

During the group discussions in the citizen workshops, participants identified the following institutions as directly or indirectly involved in the governance of the Inner Forth shoreline areas: industries; government; schools and education; citizens; and social media and technology (Fig. 3). Industries (21 times) and government (20 times) were listed most frequently as drivers of change on the Inner Forth shoreline. Fracking, driven by industries and potentially supported by the government, was discussed in all twenty groups, in terms of its impacts on the shoreline and how the industry was looking to increase local support, by offering financial compensation and organising events (Fig. 3). Illustrative quotes of citizens' knowledge and views regarding the shoreline governance are included in Fig. 3.

<< Insert Fig. 3 here >>

Social media, education and government were all seen to play a role in raising public awareness of the shoreline, which was highlighted as an important way of "increasing environmental awareness and attitudes . . . [and] train up the next generation to follow on what's been done at the moment . . . because a lot of people don't have an idea why wetlands are wetlands". It was also noted how Inner Forth residents are increasingly interested in local planning and policy, particularly young people, because more information is available to them. One group stated how important it was to:

> *Try to reconnect people with the natural. Because if there is nobody connected to it, then there is no way to care and put in the work, when the physical work needs done, who is going to sign up for it.*

3.3. How does stakeholder engagement support shoreline adaptation in the Inner Forth (RQ3)?

Our interviews suggest that stakeholders in the Inner Forth discuss and collaborate on coastal management on both local and regional levels. At a local level, stakeholders collaborate through the charity-led Inner Forth Landscape Initiative, whereas at the regional level, they collaborate through the government agency-led Forth Area Advisory Group, and the Forth Estuary Forum.

Although these institutions succeed in bringing stakeholders together, we identified three ways in which these institutions (on both local and regional levels) are limited in their capacity to support coastal adaptation: financial resources, types of stakeholders involved, and scope.

At the local level, financial resources are a limiting factor in stakeholder collaborations to support coastal adaptation. The Inner Forth Landscape Initiative works with short-term funding (2014-2018) from the Heritage Lottery. Furthermore, the scope of the landscape initiative is a limiting factor, as it works towards broader social

and environmental goals, rather than the explicitly addressing coastal adaptation. Up to now, no organisation focuses on coastal adaptation and only the RSPB has taken up the managed realignment as a central objective in their habitat restoration agenda.

At both local and regional levels, the types of stakeholders involved is a limiting factor: the farmers we interviewed said they were neither involved in collaborations or discussions on coastal adaptation, nor do they feel included in decision-making. Half of the farmers we interviewed expressed interest in being included in decision-making, and felt that "there should be, at least the local farmers and landowners, but [also] people who just stay in the country, should all be involved in deciding in what's going to happen". Some farmers, however, were reluctant to take part and did not trust local policy-makers, as expressed by one of the farmers: "they would listen to you and that is how far they would go. My husband [a farmer] has a pretty poor opinion on how bureaucracy works".

For citizens, many workshop participants stated that they currently feel overlooked and uninformed by local authorities with regards to coastal management and climate change adaptation plans. Many participants realized "it is hugely important to actually ask people in the area what they think of all of this", and that "when it comes to meetings like this, we are overlooked", and that "we could improve awareness by getting you guys to do this every week".

4. Discussion

4.1. Static defences or nature-based coastal adaptation?

Overall, citizens and locally active organisations who do not privately manage land were positive or open to managed realignment in the Inner Forth, whereas the farmers were mostly critical. There is a body of literature that compare and contrast stakeholders' attitudes towards coastal adaption (Luisetti et al. 2011; Roca and Villares 2012; Myatt et al. 2003). Yet, these papers predominantly use quantitative and monetary valuation to show citizens to be in favour of nature-based coastal adaptation for reasons of economic rationality. Our qualitative approach brings to light other dimensions and motivations, thereby supporting the findings of Martín-López et al. (2014) who suggest using diverse methods to articulate different value domains, which include but are not limited to biophysical, socio-cultural, monetary valuation. Based on the interviews with landowners, farmers and local organisations (3.1.1), and the workshops with citizens (3.1.2), we are able to articulate how static defences and nature-based coastal adaptation differ across three governance scales: individual, local community, and broader society.

On an individual level, static shoreline defences represent benefits by maintaining the reclaimed land for farming. This additonal farmland provides livelihoods for several farmers in the Inner Forth area, and it represents agricultural land, associated with food provision, cultural values and traditions that are translated into a norm or preference to not return land back to the sea. However, these individual benefits carry a societal cost in the form

of flood risks and associated damages without a natural coastal margin as a buffer. In addition, current legislation mandates that landowners are responsible to protect land from flooding, which directly translates into the continuous upkeep and maintenance of existing sea walls for farmers.

On a community level, managed realignment has potentially more benefits, because it can support restoration of up to 387 ha of wetlands (MacDonald et al. 2017) that could deliver multiple benefits, e.g. a decrease in flood risk and an increase in wildlife habitat (Myatt et al. 2003; Jones and Clark 2014; Roca and Villares 2012; Myatt-Bell et al. 2002; Ledoux et al. 2005). Therefore, managed realignment can enable more outdoor activities in nature, which residents described to contribute to their wellbeing. Discussions with the citizens, however, revealed that their support for managed realignment schemes was mainly based on their nature-regarding, or biocentric values (Davidson 2015; Morelli 2016; Weesie and van Andel 2008), rather than the cultural and regulating ecosystem services. For instance, people often rejected the idea to make the newly created wetlands accessible through paths, but preferred if these were to remain off-limits. This finding contradicts the common belief that motivations for wildlife restoration schemes cannot be solely based on biocentric arguments (Clewell and Aronson 2005; Aronson et al. 2006), and the trend for restoration to be mainly motivated by expected recreational possibilities (Adadottir et al. 2013).

On a broader societal level, the main argument for static defences is flood protection, and in the case of reclaimed lands, the additional agricultural land that can be used. MacDonald et al. (2017) calculate that if all potential sites in the Inner Forth were realigned and converted back to wetlands, the annual income lost from all agricultural land to be worth just £33,732 (excluding subsidies). The potential economic value of nature-based flood management in the Inner Forth, in terms of increasing carbon storage (£316 700 per year, MacDonald et al. 2017), wetland bird populations (£111 247, Kenter 2014), and water purifying ecosystem services (£489 234, Kenter 2014), provide greater benefits to society overall, than limited financial gains to farmers, which are subsidized by society who bears the cost of potential flooding.

4.2. Shifting governance in the context sea level rise

A transition to inclusive, deliberative and adaptive governance in estuarine and coastal areas is important in order to adapt to climate change impacts, minimize the risks of severe flooding events and the resulting property damage and risk to human lives, and enhance biodiversity benefits (Turner et al. 2016). One of the main challenges is to change the incentive structure that typically accrued benefits from land use changes such as wetland conversion to individuals, while the costs are borne by society at large. The example from the Inner Forth underlines this dilemma and the trade-offs involved. Furthermore, the private benefits of wetland conversion are often exaggerated by subsidies such as those that encourage the drainage of wetlands for agriculture or the large-scale replacement of coastal wetlands by infrastructure, such as urban and industrial development (MEA 2005).

Coastal adaptation to climate change is supported by institutions (e.g. the Inner Forth Landscape Partnership) that facilitate collaboration between local stakeholders. However, they are limited in their capacity to deal with coastal adaptation in terms of scope, finances and stakeholders involved. These deliberative institutions could address the

existing norms, which currently hinder more sustainable coastal adaptation efforts in the Inner Forth (Anguelovski and Carmin 2011).

Based on our findings and the literature, we propose three principles for stronger inclusion of important stakeholder groups that should be considered in such institutions in the Inner Forth.

i. Include farmers, because they own most of the land where managed realignment could take place (3.1.1), hold identities that contradict giving in to the sea (3.1.1), and are currently not included in coastal planning (3.3).

ii. Include citizens (Few et al. 2007; Anguelovski and Carmin 2011; Dodman and Mitlin 2011; Wamsler and Brink 2014) and particularly vulnerable groups (Lesnikowski et al. 2015), because many of them hold strong intrinsic and biocentric values for wildlife conservation (3.1.2) and currently do not feel sufficiently included in planning and decision-making (3.3).

iii. Involve industries (Aylett et al. 2010; Abel et al. 2011) that citizens identified to play a role in the governance of the Inner Forth shoreline (3.2). Including industry actors would potentially reduce the friction between interests (Granderson 2014) as well as legitimizing the process towards a sustainable coastal development.

These principles imply the need for an inclusive and participatory and deliberative planning approach, which has proved successful in planning stage of partnerships to restore rivers and deliver Water Framework Directive goals (Tippett 2005; Petts 2007; Koontz 2014) and in developing climate change adaptation plans in a range of contexts e.g. urban planning in Australia (Akompab et al. 2013), Sweden and Germany (Wamsler 2017) and wetland planning in the UK (Turner et al. 2016).

4.3. Conclusion

The Inner Forth is a place where the complex challenges of adaptation to climate change, the governance of estuarine and coastal ecosystems, and the socio-economic barriers to change all combine to reveal the underlying contradictions of the current political economy. Yet, the main industrial activity in the Inner Forth is associated with one of Europe's largest oil refineries. In some way, the image of the oil refinery with its smokestacks amidst the restored wetlands is a symbol of the contradictory logic that continues to mark many societies. On the positive side for climate mitigation, the Longannet coal-fired power plant, the single largest contributor to Scotland's greenhouse gas emissions, was recently shut down (Macalister 2016). Although this was not a direct outcome of ambitions to transition towards a more sustainable Firth of Forth, it nevertheless represents an opportunity towards a more natural state of the coastline for biodiversity habitat, flood protection and reconnecting local communities with the Forth estuary.

Rising tides mean local stakeholders need to work together more closely on shorelines, like the Inner Forth in Scotland. In some low-lying areas, shorelines may need to be intentionally realigned landwards to reduce flood

risk, however, existing governance arrangements may not support such changes. This paper has shown how citizens appreciate the socio-cultural and wildlife benefits provided by nature-based coastal adaptation, but that this change implies trade-offs for landowners' livelihoods and agricultural heritage, who perceive nature-based coastal adaptation negatively. Existing institutions for collaboration and deliberation – such as landscape partnerships and advisory groups – need to be strengthened in terms of funding, stakeholder involvement and scope, to support knowledge sharing on the local impacts of sea level rise and legitimize decision-making. These improvements in governance would also help to overcome exisiting norms amongst farmers and locally active organisations, which currently work against nature-based coastal adaptation.

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Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

We obtained informed consent from all research participants, and adequately handled their confidentiality, in line with the School of Geosciences (University of Edinburgh) Research Ethics Procedure. For the citizen workshops, the research plan was reviewed and approved by the School of Geosciences Ethics Committee and permission was obtained for photography and filming. Prior to the stakeholder interviews, participants provided consent to how the data would be used.

List of figure captions

Fig. 1 Stakeholder attitudes towards and stakes in managed realignment, drawn from the content analysis of the sixteen interviews conducted, and the citizen workshops in Alloa Town Hall. Whereas the position along the vertical axis reflects the direction and strength of the attitude, position along the horizontal axis reflects responsibility and/or vulnerability to flood risk in relative terms

Figs. 2a and 2b We interviewed seven farmers and eleven other stakeholders (2a) across the Inner Forth area, and held workshops with 109 citizens in the Alloa Town Hall (2b). Photography permissions granted by participants

Fig. 3 Institutions with an impact on the Inner Forth shoreline, as identified by the workshop participants. The frequency of mentions corresponds to the number of times each institution was to listed as a driver of change on the mind maps in the twenty breakout groups. The shade of blue indicates how many institutions are involved in driving the impact (dark = 1, medium = 2, light = 3). The relative importance of each institution is indicated by the the height of each institution, and the thickness of the line on the left

List of table captions

Table 1 Overview of the methodology for the stakeholder interviews and citizen workshops in the Inner Forth, Scotland. The corresponding research questions for each activity are indicated in brackets (RQ)

Table 2 Three main sets of norms identified from interviews with seven locally active organisations that influence their position towards nature-based shoreline adaptation schemes in the Inner Forth, and examples emerging from the interviews

References

Abel N, Gorddard R, Harman B, Leitch A, Langridge J, Ryan A, Heyenga S (2011) Sea level rise, coastal development and planned retreat: analytical framework, governance principles and an Australian case study. Environ. Sci. Policy 14:279–288. doi: 10.1016/j.envsci.2010.12.002

Adam P (2002) Saltmarshes in a time of change. Environ. Conserv. 29: 39-61. doi: 10.1017/S0376892902000048

Adger WN, Barnett J, Brown K, Marshall N, O'Brien K (2013) Cultural dimensions of climate change impacts and adaptation. Nat. Clim. Change 3:112–117. doi: 10.1038/nclimate1666

Agardy T, Alder J, Dayton P, Curran S, Kitchingman A, Wilson M, Catenazzi (2005) Coastal Systems. In: Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Current State and Trends Assessment. World Resources Institute, Washington DC

Akompab DA, Bi P, Williams S, Saniotis A, Walker I, Augoustinos M (2013) Engaging stakeholders in an adaptation process: governance and institutional arrangements in heat-health policy development in Adelaide, Australia. Mitig. Adapt. Strateg. Glob. Change 18:1001–1018. doi: 10.1007/s11027-012-9404-4

Ambros P (2016) Bridging to the common ground, adapting to climate change through sustainable estuarine land use: a study of the Inner Forth, Scotland. Master Thesis Lund University Centre for Sustainability Science

474 Anguelovski I, Carmin J (2011) Something borrowed, everything new: innovation and institutionalization in
475 urban climate governance. Curr. Opin. Env. Sust 3:169–175. doi: 10.1016/j.cosust.2010.12.017

476 Aronson J, Clewell AF, Blignaut JN, Milton SJ (2006) Ecological restoration: A new frontier for nature
477 conservation and economics. J. Nat. Conserv 14:135–139. doi: 10.1016/j.jnc.2006.05.005

478 Aylett A (2010) Conflict, Collaboration and Climate Change: Participatory Democracy and Urban
479 Environmental Struggles in Durban, South Africa. Int. J. Urban Reg. Res 34:478–495. doi: 10.1111/j.1468-
480 2427.2010.00964.x

481 Babbie ER (2013) The practice of social research. Wadsworth Cengage Learning, Belmont, California

482 Berkes F (2004) Rethinking Community-Based Conservation. Conserv. Biol 18:621–630. doi: 10.1111/j.1523-
483 1739.2004.00077.x

484 Boyes SJ, Elliott M (2014) Marine legislation – The ultimate 'horrendogram': International law, European
485 directives & national implementation. Marine Poll. Bull 86:39-47. doi: 10.1016/j.marpolbul.2014.06.055

486 Boyes SJ, Elliott M (2015) The excessive complexity of national marine governance systems – Has this
487 decreased in England since the introduction of the Marine and Coastal Access Act 2009? Mar. Policy 51:57-65.
488 doi: 10.1016/j.marpol.2014.07.019

489 Butchart S, Dieme-Amting E, Gitay H, Raaymakers S, Taylor D (2005) Ecosystems and Human Well-being:
490 Wetlands and Water Synthesis. In: Millennium Ecosystem Assessment. World Resources Institute, Washington
491 DC

492 Chmura GL, Anisfeld SC, Cahoon DR, and Lynch JC (2003) Global carbon sequestration in tidal, saline
493 wetland soils, Global Biogeochem. Cycles 17. doi:10.1029/2002GB001917,

494 City of Edinburgh Council (2016) Local Flood Risk Management Plan.

495 Clewell AF, Aronson J (2006) Motivations for the Restoration of Ecosystems. Cons. Biol 20:420–428. doi:
496 10.1111/j.1523-1739.2006.00340.x

497 ClimateXChange (2016) Flooding and Infrastructure. ClimateXChange Secretariat.
498 http://www.climatexchange.org.uk/adapting-to-climate-change/indicators-and-trends/flooding-and-
499 infrastructure. Accessed 16 June 2017

500 Colclough S, Fonseca L, Astley T, Thomas K, Watts W (2005) Fish utilisation of managed realignments. Fisher.
501 Manag. Ecol. 12:351-60. doi: 10.1111/j.1365-2400.2005.00467.x

502 Dodman D, Mitlin D (2013) Challenges for Community-Based Adaptation: Discovering the Potential for
503 Transformation. J Int. Dev 25:640–659. doi: 10.1002/jid.1772

504 Doody JP (2004) 'Coastal Squeeze': An Historical Perspective. J Coast. Cons 10:129-138. doi:
505 10.1007/bf02818949

506 Doody JP (2013) Coastal squeeze and managed realignment in southeast England, does it tell us anything about
507 the future? Ocean Coast. Manag 79:34-41. doi: 10.1016/j.ocecoaman.2012.05.008

508 Durham E, Baker H, Smith M, Moore E, Morgan V (2014) The BiodivERsA Stakeholder Engagement
509 Handbook. BiodivERsA, Paris

510 Esteves LS, Thomas K (2014) Managed realignment in practice in the UK: results from two independent
511 surveys. J Coast. Res 407–413. doi: 10.2112/SI70-069.1

512 European Commission (2013) Share of population in coastal regions living within 50km from the coastline by
513 NUTS3 regions. Eurostat. http://ec.europa.eu/eurostat/statistics-
514 explained/index.php/File:Share_of_population_in_coastal_regions_living_within_50km_from_the_coastline_by
515 _NUTS3_regions.png#filehistory. Accessed 16 June 2017

516 Few R, Brown K, Tompkins EL (2007) Public participation and climate change adaptation: avoiding the illusion
517 of inclusion. Clim. Policy 7:46–59. doi: 10.1080/14693062.2007.9685637

518 Fish R, Saratsi E (2015) Using Ecosystem Services in Public Engagement and Dialogue on the Natural
519 Environment. Living With Environmental Change.
520 http://www.nerc.ac.uk/research/partnerships/ride/lwec/ppn/ppn23/. Accessed 18 August 2017

521 Fishkin JS (2003) Consulting the public through deliberative polling. J Pol Anal Manag 22:128–133. doi:
522 10.1002/pam.10101

523 Folke C (2004) Traditional Knowledge in Social–Ecological Systems. Ecol. Soc 9:7. doi: 10.5751/ES-01237-
524 090307

525 Foster NM, Hudson MD, Bray S, Nicholls RJ (2013) Intertidal mudflat and saltmarsh conservation and
526 sustainable use in the UK: A review. J Environ. Manag 126:96–104. doi: 10.1016/j.jenvman.2013.04.015

527 French PW (2006) Managed realignment – The developing story of a comparatively new approach to soft
528 engineering. Estuar. Coast. Shelf Sci 67:409–423. doi: 10.1016/j.ecss.2005.11.035

529 Granderson AA (2014) Making sense of climate change risks and responses at the community level: A cultural-
530 political lens. Clim. Risk Manag 3:55–64. doi: 10.1016/j.crm.2014.05.003

531 Hansen M, Ramasar V, Buchanan K (2014) Localising global environmental governance norms: Implications
532 for justice. In: Sowman M, Wynberg R (eds) Governance for Justice and Environmental Sustainability: Lessons
533 across Natural Resource Sectors in Sub-Saharan Africa. Routledge. pp 43–62

534 Heritage Lottery Fund (2017) Landscape Partnerships. The National Lottery. https://www.hlf.org.uk/looking-
535 funding/our-grant-programmes/landscape-partnerships. Accessed 19 August 2017

536 Inner Forth Landscape Initiative. (2014) Welcome to IFLI. Inner Forth Landscape Iniative.
537 http://www.innerforthlandscape.co.uk. Accessed 13 March 2017

538 Jones N, Clark J (2014) Social capital and the public acceptability of climate change adaptation policies: a case
539 study in Romney Marsh, UK. Climat. Change 123:133–145. doi: 10.1007/s10584-013-1049-0

540 Juntti M, Russel D, Turnpenny J (2009) Evidence, politics and power in public policy for the environment.
541 Environ. Sci. Policy 12:207–215. doi: 10.1016/j.envsci.2008.12.007

542 Koontz TM (2014) Social learning in collaborative watershed planning: the importance of process control and
543 efficacy. J. Environ. Plan. Manage 57:1572–1593. doi: 10.1080/09640568.2013.820658

544 Kenter JO (2014) Valuing the Inner Forth. Final report for the Inner Forth Landscape Initiative.
545 http://innerforthlandscape.co.uk/files/KenterValuingtheInnerForth.pdf Accessed 28 January 2018

546 Kenter JO (2016) Integrating deliberative monetary valuation, systems modelling and participatory mapping to
547 assess shared values of ecosystem services. Ecosyst. Serv 21:291-307. doi: 10.1016/j.ecoser.2016.06.010

548 King SE, Lester JN (1995) The value of salt marsh as a sea defence. Marine Pollut. Bull 30:180–189. doi:
549 10.1016/0025-326X(94)00173-7

550 Ledoux L, Cornell S, O'Riordan T, Harvey R, Banyard L (2005) Towards sustainable flood and coastal
551 management: identifying drivers of, and obstacles to, managed realignment. Land Use Policy 22:129–144. doi:
552 10.1016/j.landusepol.2004.03.001

553 Lesnikowski AC, Ford JD, Berrang-Ford L, Barrera M, Heymann J (2015) How are we adapting to climate
554 change? A global assessment. Mitig. Adapt. Strateg. Glob. Change 20:277–293. doi: 10.1007/s11027-013-9491-
555 x

556 Liski AH, Koetse MJ, Metzger MJ (2019) Addressing awareness gaps in environmental valuation: choice
557 experiments with citizens in the Inner Forth, Scotland. Reg. Environ. Change. doi: 10.1007/s10113-018-01458-
558 4

559 Lowe JA, Howard TP, Pardaens A, Tinker J, Holt J, Wakelin S, Milne G, Leake J, Wolf J, Horsburgh K, Reeder
560 T, Jenkins G, Ridley J, Dye S, Bradley S (2009) UK Climate Projections science report: Marine and coastal
561 projections. Met Office Hadley Centre.
562 http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87905&. Accessed 19 August 2017

563 Luisetti T, Turner RK, Bateman IJ, Morse-Jones S, Adams C, Fonseca L (2011) Coastal and marine ecosystem
564 services valuation for policy and management: Managed realignment case studies in England. Ocean Coast.
565 Manag. 54:212–224. doi: 10.1016/j.ocecoaman.2010.11.003

566 Macalister T (2016) Longannet power station closes ending coal power use in Scotland. The Guardian.
567 https://www.theguardian.com/environment/2016/mar/24/longannet-power-station-closes-coal-power-scotland.
568 Accessed 19 August 2017

569 MacDonald MA, de Ruyck C, Field RH, Bedford A and Bradbury RB (2017) Benefits of coastal managed
570 realignment for society: Evidence from ecosystem service assessments in two UK regions. Estuar. Coast. Shelf
571 Sci. (in press) https://doi.org/10.1016/j.ecss.2017.09.007

572 Martín-López B, Gómez-Baggethun E, García-Llorente M, Montes C (2014) Trade-offs across value-domains
573 in ecosystem services assessment. Ecol Indic 1:220-8. doi: 10.1016/j.ecolind.2013.03.003

574 McGranahan G, Balk D, and Anderson B (2007) The rising tide: Assessing the risks of climate change and
575 human settlements in low elevation coastal zones. Environ. Urban 19:17-37. doi: 10.1177/0956247807076960

576 Midgley S, McGlashan DJ (2004) Planning and management of a proposed managed realignment project:
577 Bothkennar, Forth Estuary, Scotland. Marine Policy 28:429-435. doi: 10.1016/j.marpol.2003.10.018

578 Milfont TL (2012) The Interplay Between Knowledge, Perceived Efficacy, and Concern About Global
579 Warming and Climate Change: A One-Year Longitudinal Study. Risk Anal 32:1003–1020. doi: 10.1111/j.1539-
580 6924.2012.01800.x

581 Milligan J, O'Riordan T, Nicholson-Cole SA, Watkinson AR (2009) Nature conservation for future sustainable
582 shorelines: Lessons from seeking to involve the public. Land Use Policy 26:203–213. doi:
583 10.1016/j.landusepol.2008.01.004

584 Morelli F, Tryjanowski P, Benedetti Y (2016) Differences between niches of anthropocentric and biocentric
585 conservationists: Wearing old clothes to look modern? J Nat. Conserv 34:101–106. doi:
586 10.1016/j.jnc.2016.09.005

Morris, RKA (2013) Managed realignment as a tool for compensatory habitat creation – A re-appraisal. Ocean Coast. Manag 73:82-91. doi: 10.1016/j.ocecoaman.2012.12.013

Myatt LB, Scrimshaw MD, Lester JN (2003) Public perceptions and attitudes towards an established managed realignment scheme: Orplands, Essex, UK. Journal of Environmental Management 68:173–181. doi: 10.1016/S0301-4797(03)00065-

Myatt-Bell LB, Scrimshaw MD, Lester JN, Potts JS (2002) Public perception of managed realignment: Brancaster West Marsh, North Norfolk, UK. Marine Policy 26:45–57. doi: 10.1016/S0308-597X(01)00033-1

Möller I, Kudella M, Rupprecht F, Spencer T, Paul M, Van Wesenbeeck BK, Wolters G, Jensen K, Bouma TJ, Miranda-Lange M, Schimmels S (2014) Wave attenuation over coastal salt marshes under storm surge conditions. Nat. Geosci. 7:727-31. doi: 10.1038/ngeo2251

North D (1990) Institutions, Institutional Change and Economic Performance. Cambridge University Press, Cambridge

Oxford English Dictionary Online (2017a) Norm, n.1. Oxford University Press. http://www.oed.com/view/Entry/128266. Accessed 21 June 2017

Oxford English Dictionary Online (2017b) Institution, n. Oxford University Press. http://www.oed.com/view/Entry/97110. Accessed 21 June 2017

Petts J (2007) Learning about learning: lessons from public engagement and deliberation on urban river restoration. The Geographical Journal 173:300–311. doi: 10.1111/j.1475- 4959.2007.00254.x

Pirie D (2017) Taking Stock - Where we are now. Conference Presentation at the Sniffer Flood Risk Management Conference 2017. Sniffer. https://www.sniffer.org.uk/flood-risk-management-conference-2017. Accessed 16 June 2017

Rennie AF, Hansom JD (2011) Sea level trend reversal: Land uplift outpaced by sea level rise on Scotland's coast. Geomorphology 125:193–202. doi: https://doi.org/10.1016/j.geomorph.2010.09.015

Roca E, Villares M (2012) Public perceptions of managed realignment strategies: The case study of the Ebro Delta in the Mediterranean basin. Ocean Coast. Manag 60:38–47. doi: 10.1016/j.ocecoaman.2012.01.002

Roebeling PC, Costa L, Magalhães-Filho L, Tekken V (2013) Ecosystem service value losses from coastal erosion in Europe: Historical trends and future projections. J Coast. Conserv 17:389-395. doi: 10.1007/s11852-013-0235-6

Rogers S, Kaiser M, Jennings S (1998) Ecosystem effects of demersal fishing: A European perspective. In: Dorsey EM, Pederson J (eds) Effects of Fishing Gear on the Sea Floor of New England. Conservation Law Foundation, Boston, pp 68-79

Scavia D, Field JC, Boesch DF, Buddemeier RW, Burkett V, Cayan DR, Fogarty M, Harwell MA, Howarth RW, Mason C, Reed DJ, Royer TC, Sallenger AH, Titus JG (2002) Climate Change Impacts on U. S. Coastal and Marine Ecosystems. Estuaries 25:149-164. doi: 10.1007/BF02691304

Scottish Environment Protection Agency (2015) Flood Risk Management Strategy Forth. Scottish Environment Protection Agency. http://apps.sepa.org.uk/FRMStrategies/pdf/lpd/LPD_10_Full.pdf. Accessed 19 August 2017

Scottish Government (2014) Scottish Planning Policy. Scottish Government. http://www.gov.scot/Publications/2014/06/5823. Accessed 16 June 2017

Scottish Government (2016a) Draft Budget 2016. http://www.gov.scot/Publications/2015/12/9056/8. Accessed 11th October 2017

Scottish Government (2016b) Flood Risk Management (Scotland) Act 2009. Scottish Government. http://www.gov.scot/Topics/Environment/Water/Flooding/FRMAct. Accessed 16.06.2017

Scottish Natural Heritage (2011) Firth of Forth - Site of Special Scientific Interest: Site Management Statement. Scottish Natural Heritage. http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8163#links. Accessed 19 August 2017

Small C, Nicholls RJ (2003) A Global Analysis of Human Settlement in Coastal Zones. J Coast. Res 19:584-599

Smout TC, Stewart M (2012) The Firth of Forth: An Environmental History. Birlinn, Edinburgh

Spalding MD, McIvor AL, Beck MW, Koch EW, Möller I, Reed DJ, Rubinoff P, Spencer T, Tolhurst TJ, Wamsley TV, Wesenbeeck BK (2014) Coastal Ecosystems: A Critical Element of Risk Reduction. Conserv. Lett. 7:293–301. doi: 10.1111/conl.12074

Spencer KL, Harvey GL (2012) Understanding system disturbance and ecosystem services in restored saltmarshes: Integrating physical and biogeochemical processes. Estuar. Coast. Shelf Sci 106:23-32. doi: 10.1016/j.ecss.2012.04.020

Swart R, Biesbroek R, Lourenço TC (2014) Science of adaptation to climate change and science for adaptation. Front. Environ. Sci doi: 10.3389/fenvs.2014.00029

Tippett J, Searle B, Pahl-Wostl C, Rees Y (2005) Social learning in public participation in river basin management—early findings from HarmoniCOP European case studies. Environ. Sci. Policy 8:287–299. doi: 10.1016/j.envsci.2005.03.003

Turner RK, Palmieri MG, Luisetti T (2016) Lessons from the construction of a climate change adaptation plan: A Broads wetland case study. Integr Environ Assess Manag: 12: 719–725. doi: 10.1002/ieam.1774

Turner RK, Burgess D, Hadley D, Coombes E, and Jackson N (2007) A cost-benefit appraisal of coastal managed realignment policy. Glob. Environ. Change 17:397-407. doi: 10.1016/j.gloenvcha.2007.05.006

UK Committee on Climate Change (2016) UK Climate Risk Assessment 2017. Committee on Climate Change. https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017. Accessed 16 June 2017

Wamsler C (2017) Stakeholder involvement in strategic adaptation planning: Transdisciplinarity and co-production at stake? Environ. Sci. Policy 75:148–157. doi: 10.1016/j.envsci.2017.03.016

Wamsler C, Brink E (2014) Interfacing citizens' and institutions' practice and responsibilities for climate change adaptation. Urban Climate 7:64–91. doi: 10.1016/j.uclim.2013.10.009

Weesie PDM, Van Andel J (2008) An Integrated Framework for the Instrumental Valuation of Nature. Rest. Ecol 16:1–4. doi: 10.1111/j.1526-100X.2007.00353.x

Wiering MA, Arts BJM (2006) Discursive Shifts in Dutch River Management: "Deep" Institutional Change or Adaptation Strategy? Hydrobiol 565:327–338. doi: 10.1007/s10750-005-5923-2

Williamson O (2000) The New Institutional Economics: Taking Stock, Looking Ahead. J Econ Lit 38:595-613. doi: 10.1257/jel.38.3.595

662 Wilson MA, Howarth RB (2002) Discourse-based valuation of ecosystem services: establishing fair outcomes
663 through group deliberation. Ecol. Econ 41:431–443. doi: 10.1016/S0921-8009(02)00092-7

664 Zhu X, Linham MM, Nicholls RJ (2010) Technologies for climate change adaptation-Coastal erosion and
665 flooding. Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energ. http://www.tech-
666 action.org/Publications/TNA-Guidebooks. Accessed 19 August 2017